TOLYPELLA NORMANIANA NORDSTEDT, A LITTLE KNOWN CHAROPHYTE FROM NORTHERN NORWAY

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ABSTRACT- *Tolypella normaniana* is a charophyte endemic to Northern Norway. It is only known from a few localities in Nordland county, but is presumed to be more widespread in the area as there are many potential localities. In this paper specimens from three localities in Nordland are treated. The different populations are described separately, as the local variation is considerably. The alga is specially well adapted to live on the tidal flats in estuaries in the area. On these foreshore flats the competition from other plants is minimal. One important chemical factor in this environment is salt content, which vary considerably during the year. In a simple growth experiment the alga did not change phenotypical from how it was found in nature. This was in contrast to *Chara aspera*, which in the same experiment changed phenotypical from dwarf to "normal".

The belonging of this species to the section *Obtusifolia* of *Tolypella* is discussed, and the species has been compared to other "extreme" taxa in the section. A possible migration route for the taxon is mentioned .

RÉSUMÉ- *Tolypella normaniana* est une charophyte endémique du nord de la Norvège. On sait qu'elle est présente en des zones limitées de la région du Nordland. On suppose, par ailleurs, que sa présence est possible dans de nombreuses autres localités de cette zone. Des specimens en provenance de trois localités sont traités dans ce document. Ces specimens sont décrits séparément, du fait des variations locales. L'algue s'adapte tout particulièrement bien à la vie marécageuse (zones de marées basses) dans les estuaires. En zones marécageuses, la compétition avec d'autres plantes est limitée. Dans un tel environnement, la teneur en sel, qui varie considérablement pandant l'année, est un facteur chimique important. Au cours d'une simple expérience de croissance, l'algue n'a pas subi de changements phénotypiques par rapport à son état dans la nature. Au contraire, durant cette même expérience, *Chara aspera* a subi des changements pour passer d'un état "nain" à un état "normal".

L'appartenance de ces espèces à la section *Obtusifolia* de *Tolypella* est sujette à discussion, et les espèces ont été comparées à d'autres taxons "extrêmes" de la section. Une voie de migration possible du taxon est mentionnée.

KEY WORDS - *Tolypella normaniana*, *Chara aspera*, *Northern Norway*, tidal flats.

INTRODUCTION

Tolypella normaniana Nordstedt was collected for the first time by the Norwegian botanist J.M. Norman in Beiarn-fjorden, Nordland in 1867 (Norman, 1894).

It was described as a new species by the Swedish charologist Otto Nordstedt in 1868 (Nordstedt, 1868). Later the species has also been found in a few other fjords in Nordland (see below). Specimens of *T. normaniana* from Beiarn-fjorden are found in exsicatae of Nordstedt & Wahlstedt (1871) and Braun, Rabenhorst & Stizenberger (1878). In his monography of Norwegian and Swedish charophytes Wahlstedt (1875) considers *T. normaniana* as a form of *Tolypella nidifica* (Müller) v.Leonh. This is the first time the validity of the species was queried. In his work on oospore membranes Nordstedt (1880) still treats it as a species. But in a later work Nordstedt reduces the taxon to a subspecies of *Tolypella nidifica* (Braun & Nordstedt, 1883). This has been followed by many authors at a later date (Groves & Bullock-Webster,1920; Hasslow, 1936; Corillion,1957; Wood, 1962; Moore, 1986). Sydow (1882) even treats it as a variety of *Tolypella glomerata* Desv. in Lois. This contrasts with Migula (1897) who considers *Tolypella normaniana* as a good species. Description of the species (based on material from Beiarn-fjorden) is found in Norman (1868) (referred in Fries, 1868), Nordstedt (1883) (drawings only), Wood & Imahori (1964-1965).

MATERIAL AND METHODS

Specimens of *Tolypella normaniana* were collected during summer of 1992 and 1993. They were kept in a 3% formalin solution. In the autumn of 1993 living specimens were send to me from two contacts in the area.

Water samples were taken in bottles for water analyses. Conductivity,salt content and pH were measured on the spot. Conductivity and salt content were measured with a Hach Conductivitymeter Model 44600/CND/TDS Meter, pH with a Hellige Comparator. Chloride and calcium were measured with Aquamerck 11106 Chloride and Aquamerck 11110 Calcium.

In the growth experiment I used water and bottom sediment from Sørfjorden, and specimens of *Chara aspera* Deth ex Willd. (from Sørfjorden) and *Tolypella normaniana* (from Beiarn-fjorden). Small pieces of these algae were put in the culture glass, and covered with a thin layer of sediment.

A chromosomal count was done on material from Beiarn-fjorden, collected 01.08.1993. Young antheridia were dissected out, and stained in aceto-orcein and then squashed.

All specimens studied here are deposited in the phycological herbarium at Botanical Museum, University of Oslo (O).

RESULTS

A. Description of the localities

I have collected *Tolypella normaniana* in three different locations. These three localities have this in common: - They are estuaries in fjord heads. - These fjord heads receive great quantities of fresh water from big rivers and are therefore brackish. - The tidal differences are great, between 1-3 m., and in the estuaries large areas are exposed

to air at ebb making up tidal flats (Fig. 14). On these tidal- or foreshore flats the alga grows. The charophytes are fastened by their rhizoid system and the phanerogames with roots. Different other algae grow on stones or shells, while filamentous algae drift around in the water.

Leirvika, Beiarn-fjorden (Fig. 1).

Clay bottom with silt on top. *Tolypella normaniana* grows in very dense mats and cover great areas. Big quantities of different filamentous algae, *Cladophora* sp., *Zygnema* sp., *Spirogyra* sp., *Oedogonium* sp., *Percursaria percursa* (Ag.) Rosenvinge, *Vaucheria medusa* Christensen, *Bulbochaete* sp., *Tribonema* sp., *Enteromorpha* sp. *Ruppia maritima* L. is common.

Breidvika and Sagneset (Bjerka), Sørfjorden (Figs. 2 and 14).

A thin layer of silt, 1-2 cm thick, covers a hard clay bottom. *Tolypella normaniana* and *Chara aspera* were growing in scattered patches, especially well in

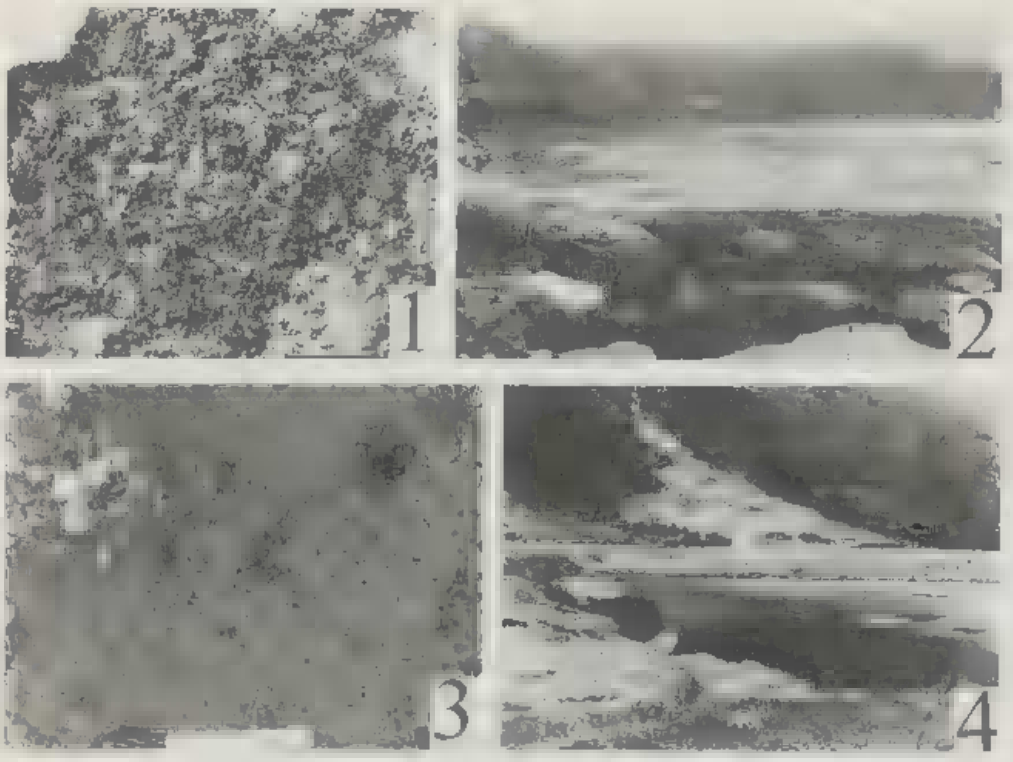

Figure 1. - Beiarn-fjorden. *Tolypella normaniana* covers the bottom in dense mats. The scale is c. 5 cm. Photo 13.07.1993.

Figure 2. - Sørfjorden by Breidvika. Part of the shore with the foreshore flat. Photo 17.07.1993.

Figure 3. - Mosjøen. *T.normaniana* growing on fine sand bottom, seen as small dark dots. The big plants are *Cochlearia ssp. norvegica*. The pen is 13 cm long. Photo 17.07.1993.

Figure 4. - Mosjøen. Part of the locality shown here is filled in with stones and soil. It is only a question of time before this locality will be destroyed. Photo 17.07.1993.

areas with small pools created by ebb sea. *Potamogeton filiformis* Pers., *Eleocharis uniglumis* (Link) Schultes and the brown alga *Pelvetia canaliculata* (L.) Dcne. et Thur. were accompanying the charophytes. Near the shore *Pedicularis palustris* L. and *Carex paleacea* Wahlenb. were common.

The outlet of the river Vefsna in Mosjøen, Vefsnfjorden (Fig. 3)

A more sandy bottom is found here. On the foreshore flats *Tolypella normaniana* was discovered scattered both in small pools and exposed to air on the wet bottom sediment. *Cochlearia officinalis* L. subsp. *norvegica* Nordal et Stabbetorp was commonly accompanying *T. normaniana* (Fig.3). Filamentous algae were *Zygnema* sp., *Spirogyra* sp. and *Cladophora* sp.

Due to lack of space for industry this area is partly filled in with stones and soil. In a few years from now the locality will be destroyed and the alga will most probably die out (Fig. 4). The two other localities, Beiarn-fjorden and Sørfjorden have recently been evaluated to have very high protective value (Elven *et al.*, 1988).

B. Description of the populations studied

The Mosjøen population, specimens collected 17.07.1993 (Figs. 5 and 7).

Plants small up to 19 mm high, up to 9 plants in the same protonema. Not encrusted and dark green in colour. Protonemal internode 2-7 mm long, often with oospore. The plants are growing out from one or two root nodes, and are commonly in different developmental stages. Protonemal axis 150-300 µm in diameter. Whorls 1-5. Protonemal whorl always with fertile, branched branchlets, and often with sterile, unbranched branchlets. Fertile branchlets 4-10, are up to 9 mm long. Sterile branchlets, unbranched 1-4 up to 14 mm long . One protonemal terminal process (Vorkeimspitze), thicker than the branchlets and as thick as, or slightly thicker than the protonemal internodium, and much longer than the head (which gives the species a peculiar look) up to 15 mm long, 3-5 celled.The other whorls only with fertile branchlets. On the first whorl 7-9 branchlets, 1-6 mm long. On the second whorl 5-8 branchlets, 1-4 mm long. The branchlets are normaly curved inwards towards the stem.

Internode between the protonemal whorl and the first whorl vary from 0,5-2 mm in length. Other internodes are much shorter.

Branchlets of the protonemal whorl 3-8 X the length of internode. Sideshoots are often found in the protonemal whorl, 1-2. In other whorls sideshoot is not common.

Fertile branchlets with 2-3 lateral rays (most common 3) at lowest node. Branchlets 5X - 10X the length of the basal cells. End segments 2-5 X as long as the lateral rays, 2-4 celled. End cells obtuse, shorter and smaller than the penultimate cell.

Rays 2-4 celled (most commom 3), curved inwards, 0,5 - 3mm. End cells the shortest cells in rays, obtuse. Secondary rays are found.

Heads commonly found, but not always, 0.5-7mm in diameter, without mucus. The species normaly fructify in very rich quantities. Monoecious. Gametangia conjoined at stem nodes and at fertile branchlet nodes. Specimens in this collection are markedly protandrous, with big antheridia and many small oogonia. Generally one antheridium and two lateral oogonia, but also other combinations are common; three antheridia/one oogonium- two antheridia/one oogonium- 4 antheridia.

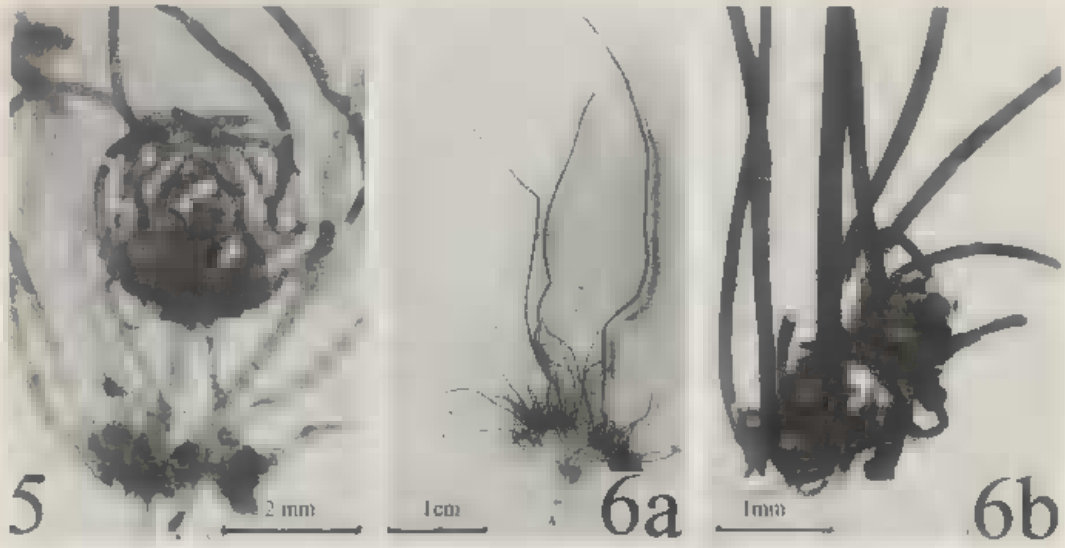

Figure 5. - Mosjøen. Specimens of *T. normaniana* collected 17.07.1993. Part of a specimen showing protonemal whorl and first internode which is 2 mm long and with two more whorls forming a small head. The branchlets are all curved inwards.
Figure 6. - Sørfjorden. Specimens of *T. normaniana* collected 13 and 17.07.1993. a. Specimen with 7 plants. Total length 60 mm. This is mainly due to the extra length of the protonemal terminal processes. b. Close up photo of the head of one specimen. The antheridia at the left side are stalked. The endsegments of the branchlets are extra long. The thick cell in the middle is the protonemal terminal process.

Oogonia 300-350 µm long (included coronula), 170-290 µm wide, 7-8 convolutions. Coronula 40-50 µm high, 80 µm wide at base. Most oogonia without stalkcell, but in some up to 150 µm long. Oospores not mature.

Antheridia most often solitary, but also up to four together, 250- 370 µm in diameter, short stipitate with stalkcell up to 150 µm long.

Specimens studied: VEFSN: Vefsnas outlet in Mosjøen, 17.07.1993 A.L.

The Sørfjorden (Bjerka) population, specimens collected in 1993 (Figs. 6 and 8)

Plants up to 100 mm high (58 mm in average/15 measures), up to 20 plants in the same protonema (variation 3-20, 10 in average/8 measures). Not encrusted. Green to dark green colour. Protonemal internode 4-37.5 mm long (12 mm average/ 11 measures), often with oospore. The plants grow from one to three root nodes, and they occur in different developmental stages.

Protonemal axis 150-450 µm in diameter. Whorls 1-5 (with 4 as most common). Protonemal whorl always with fertile branchlets, and often with sterile, unbranched branchlets. Fertile branchlets (incl. accessory) 4-22 (11 in average/6 measures), up to 40 mm long (20 mm in average/9 measures), 2-4 celled. Sterile branchlets 2-6, up to 9 mm long. One protonemal terminal process, seems like a prolongation of the

Figure 7. - Mosjøen. Specimens of *T. normaniana* collected 17.07.1993. Specimen with 8 plants from the same protonema. The germinated oospore is still fastened to the plant. Total length of the plant is 15 mm.

Figure 8. - Sørfjorden. Specimens of *T. normaniana* collected 13 and 17.07.1993. a. Specimen with 4 plants. The right plant is best developed. It has three whorls in addition to the protonemal whorl. Total length of the alga is 23 mm. b. Different branchlets. *1*. with three rays *2*. with four rays *3*. more complicated with secondary rays *4*. Gametangia (here 2 oogonia and 1 antheridium).

Figure 9. - Beiarn-fjorden (cf. fig. 11) Regular branchlet with 3 rays, and one accessory branchlet from protonemal whorl.

Figure 10 - *Chara aspera* collected in Sørfjorden 30.09.1993. Notice the long protonemal terminal process.

protonemal internodium, and is often as thick as this, and thicker than the branchlets, up to 90 mm long (60 mm in average/10 measures), 2-3, 3-4 or even 5-celled (the longest cell measured by me was 50 mm long). Terminal process 3-6X length of branchlets. The other whorls only with fertile branchlets. On the first whorl 4-9 branchlets, 2- 15 mm long, 3-4 celled. On the second whorl 4 - 10 branchlets 2-6 mm long. On one specimen I found two more whorls. On the third whorl 6 branchlets, to 2 mm long. On the fourth whorl 7 branchlets, to 1.2 mm long. The branchlets are normally curved inwards towards the stem.

Internode between the protonemal whorl and the first whorl vary from 0.5-2.5 mm in length (1.2 mm in average/7 measures).

Branchlets of the protonemal whorl 3-20X the length of the internodium. The next internodium to 0.5 mm in length. 1-3 sideshoots may be found in all whorls but they are not common.

Fertile branchlets with 2- 3 or 3-4 (in one case 5) lateral rays (3 most common) at lowest node. Branchlets 3 - 30X the length of the basal cells. End segment 3-25X as long as the lateral rays, 2-3 celled. End cells obtuse, shorter and smaller than the penultimate cells, 2-3 celled.

Rays 2-3 celled (most common 3), curve inwards, 0.5-9 mm. End cells the shortest cells in rays, obtuse. Secondary rays with gametangia on base can be found.

Heads commonly found , 2-9 mm in diameter, without mucus.

The species always fructify very richly. Monoecious. Gametangia conjoined at stem nodes and at fertile branchlet nodes. Generally one antheridium and two lateral oogonia, but many other combinations are found, 4 oogonia/one antheridium, 3 oogonia/2 antheridia, 3 oogonia/1 antheridium 5 oogonia/1 antheridium, 4 antheridia.

Oogonia 350-500 µm long (included coronula), 300-400 µm wide, 7-8 convolutions. Coronula 40-50 µm high, 80-100 µm wide at base. Most oogonia without stalkcell, but in some up to 250 µm long. Oospores dark brown to black, 280-300 µm long, 250-300 µm wide, with 7-8 sharp ridges. Fossae c. 45 µm across, membrane fine granulated.

Antheridia most often solitary, but in clusters of up to 4, 280-400 µm in diameter, short stipitate. In some cases with stalkcell up to 300 µm long.

Specimens studied: HEMNES: Sørfjorden by Sagneset 13.07.1993 A.L.02.08.1993, 25.08.1993 and 30.09.1993 Viggo Davidsen , Sørfjorden by Breidvika 17.07.1993 A. L.,

The Beiarn-fjorden (Leirvika) population, specimens collected in 1992 and 1993 (Figs. 11 and 9)

Plants up to 55 mm high (40 mm in average/14 measures), 1- 4 plants (mostly only one) on the same protonema. Encrusted, often heavily grey in colour. Specimens collected in november were not encrusted, they were green in colour. Protonemal internode 9-29 mm long (16 mm in average/13 measures), often with oospore. Protonemal axis 300-600 µm in diameter. Whorls 2-6 (most often 4-5). Protonemal whorl always with fertile branchlets, and with sterile, unbranched branchlets. Fertile branchlets 5-20 (13 in average/9 measures) (with 2-8 accessory included), up to 40 mm long. Sterile branchlets 3. One protonemal terminal process (Vorkeimspitze), most often thicker than or as thick as the branchlets and thinner or as thick as the protonemal internodium. The terminal process is higher to much higher than the heads, and up to 38 mm long. The other whorls mostly with fertile branchlets, and in some specimens with 1 sterile branchlet. On the first whorl 5-10 branchlets, 7-12 mm long. On the secondary whorl 5-8 branchlets, 3-6 mm long. In one specimen whorl 3 with 5, whorl 4 with 3 and whorl 5 with 3 branchlets (100 µm long). The branchlets are normaly curved inwards towards the stem.

Internode between the protonemal whorl and the first whorl varying from 3-26 mm in length. Other internodes are shorter. Sideshoots can often be found in all whorls, but they are best developed in the protonemal whorl. In some cases the sideshoots can be equal in size with the mainshoot (Fig. 11b).

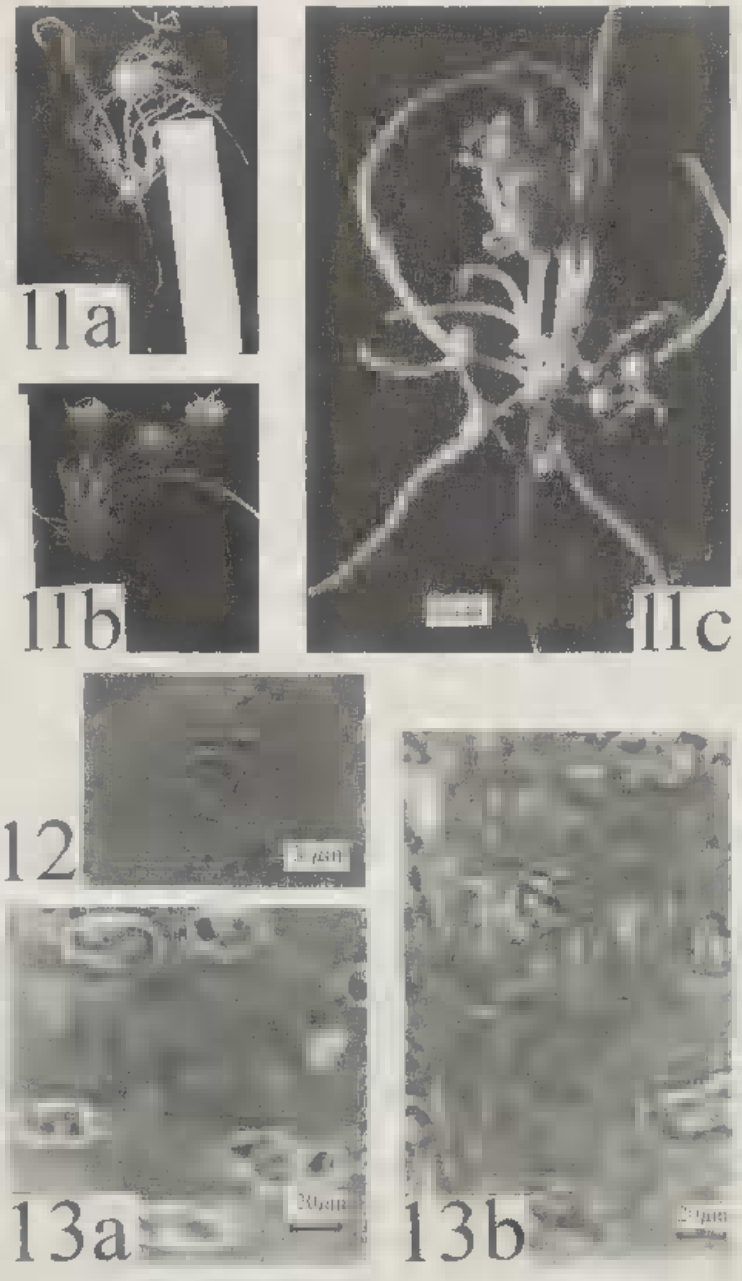

Figure 11. - Beiarn-fjorden. Specimens of *T. normaniana* collected 18.07.1992 and 13.07.1993. a. Specimen one mainshoot from the protonemal whorl. Hight 50 mm. The first internode is 20 mm long. (Material from 18.07.1992). b. Specimen with four shoots from the protonemal whorl. Total hight 50 mm. The longest first internode (plant to the right) is 26 mm long. (Material from 18.07.1992). c. Incrustated specimen collected 13.07.1993. First internode is 10 mm long. The protonemal whorl has 8 regular branchlets and 2 accessory branchlets.
Figure 12. - Chromosomes of *Tolypella normaniana*. n = c. 20.
Figure 13. - "Callose" pits a) *Tolypella nidifica*, b) *Tolypella normaniana*.

Branchlets of the protonemal whorl 1-6 X the length of the internodium. Fertile branchlets with 3-4 lateral rays (most common 3) at lowest node. Branchlets 5-10 X the length of the basal cells. End segment 1-4 X as long as the lateral rays, 3-4 celled. End cells obtuse, shorter and smaller than the penultimate cell.

Rays 2-4 celled (most common 3) at lowest node, curved inwards, 0.5-2 mm. End cell the shortest cell in the ray, obtuse.

Heads are commonly found, 1-3, 2-12 mm in diameter, without mucus. Monoecious. Gametangia conjoined at stem nodes and at lowest node of fertile branchlets. Stem nodes normally with many gametangia both below and above the branchlets. Fertile branchlets generally with one antheridium and two lateral oogonia, but many other combinations are possible.

Oogonia 380-450 µm long (included coronula), 300-380 µm wide, 7-8 convolutions. Coronula 30-40 µm high, 80 µm wide at base. Oospore 280-300 µm long, 230-280 µm wide with 6-8, low sharp ridges. Oospore with 2 basal impressions.

Antheridia solitary or 2-3 together, 300-450 µm in diameter, when stipitated with stalkcell up to 600 µm.

Specimens studied: BEIARN : Leirvika in Beiarn-fjorden 18.07.1992 A.L. 13.07.1993 A.L., 01.08.1993 and 07.11.1993 Mats Nettelbladt.

General description of the species

Based on the description of the three populations examined, *Tolypella normaniana* can be described as follows:

Plants up to 100 mm high, 1-20 plants in the same protonema. Encrusted or not encrusted. Protonemal internode 2-37.5 mm long, *axis* 150-600 µm in diameter. Whorls 1-6. Protonemal whorl always with fertile branchlets, and with sterile, unbranched branchlets. Fertile branchlets 4-22, up to 40 mm long. Sterile branchlets, 1-6. One protonemal terminal process, much longer than the heads, up to 90 mm long. The other 1-5 whorls only with fertile branchlets. The branchlets are normally curved inwards towards the stem.

Internode between the protonemal whorl and the first whorl vary from 0.5-26 mm.

Heads commonly found, but not always, 0.5-12mm in diameter, without mucus.

Monoecious. Gametangia conjoined at stem nodes and at fertile branchlet nodes. Oogonia 300-450 µm long (included coronula), 170-400 µm wide, 7-8 convolutions. Some oogonia with stalkcell up to 250 µm long. Oospore dark brown to black, 230-300 µm long, 230-300 µm wide, with 6-8 sharp ridges. Oospore with 2 basal impressions. Fossae c. 45µm across, membrane fine granulated.

Antheridia solitary or 2-4 together, 250-450 µm in diameter, when stipitated with stalkcell up to 600 µm long.

C. Growth experiment

Chara aspera

Specimens of *Chara aspera* have only been discovered in Sørfjorden. Only juvenile forms were found. They are 6-14 mm high, sterile and with many plants on the same protonema. The protonemal internode is long and always without a cortex. Other

internodes, 1-3, with cortex and spine-cells. Stipulodes are also found on nodes. Cortex on the 1-2 lowest segments of the branchlets. Very typical for these juvenile forms is the long protonemal terminal process, which is much higher than the plant (Fig. 10). This gives the plant a similar appearance to *Tolypella normaniana*.

In material collected in Sørfjorden 30.09.1993 I found three small specimens of *C. aspera*. These plants were placed in a glass with sediment and water from the locality. After two months (23.11.93) the plants had developed into normal types of *C. aspera,* to 9 cm high. They were sterile.

In another experiment (started 26.11.93) the above plants of *C. aspera* were cut into pieces, 2-3 cm long . These pieces were put in the same glass and covered by a thin layer of sediment. On 02.01.94 many new plants of *C. aspera* had grown out from the pieces. Fertile specimens of these were the normal male type of *C. aspera*, and were up to 10 cm high.

Tolypella normaniana

Pieces of different specimens of *T. normaniana*, collected in Beiarn-fjorden 07.11.93, were on 26.11.93 planted in the glass with *C. aspera* mentioned above.

The growth of the species was good. When I examined some specimens on 03.02.94 I found many brown oospores. The plants were slightly encrusted, and more or less "normal", ■ one finds them occuring in nature. They differed only in having a longer protonemal internode, up to 50 mm long.

D. Cytology

The chromosome number was counted to n ■ c. 20 (Fig. 12). The cell examined is presumably an antheridial initial cell, and not from the antheridial filaments (Roberts & Chen, 1975).

E. "Callose" pits

"Callose" pits is a feature found only in *Tolypella*. The phenomena was first reported by Fridvalszky (1958) and later by Sawa & Markoff (1982). The inner cell wall of internodia of *T. normaniana* and *T. nidifica* were examined under phase-contrast microscope (Fig. 13). The "callose" pits have an elliptical/irregular form and are more or less parallel arranged in both species. My observations are to few to say anything about the taxonomic value of this character on species level.

F. Some ecological and biological observations

Tolypella normaniana grows on loose clay bottom in different estuarine fjords in Nordland. By ebb sea, the tidal flats which make up great areas where the alga lives are exposed to air (Figs. 2 and 14). On these foreshores flats the alga survive in small pools or on wet bottom sediment, where the alga is fastened by its rhizoids. In Mosjøen and Sørfjorden the alga grows scattered, and here the number of plants growing out from each oospore can be as high as 20. In Beiarn-fjorden the alga grows in very dense mats (Fig. 1), and here presumably due to this the number of plants from each oospore is much lower, 1-4.

In localities where *T. normaniana* lives competition from other plants (cf. the description of the localities) seems to be very small except maybe in Beiarn-fjorden where dense growth of filamentous algae may affect the growth of the alga.

T. normaniana is annual and survives the winter as oospores. The germination of charophyte oospores is regulated both by anaerobic conditions, temperature and light (Carr & Ross,1963; Forsberg, 1965 and Proctor, 1967), and is therefore set by the climatic conditions every spring. In July 1993 the alga in Mosjøen and Sørfjorden were markedly protandrous, a phenomenon well known for charophytes. In Beiarn-fjorden the alga was better developed in July 1993, presumably due to higher temperatures in the water. The fructification was extremely rich with mature red/orange oogonia and orange antheridia. In August 1993 the growth was still good, and both in Sørfjorden and in Beiarn-fjorden the first ripe, brown oospores were found.

In September 1993 the Sørfjorden population was still fructifying extremely richly, still with both oogonia and antheridia. The number of ripe oospores is still low. In November 1993 the number of ripe oospores in material from Beiarn-fjorden was much higher, but still there were fructifying specimens, now only with oogonia. In November/December the fjords will normaly be frozen, and conditions will be radically changed for the alga. The movement of ice is also an ecological gradient, but was not observed by me. The result is that the alga manages to survive the winter alone with oospores.

Some chemical parameters from the localities are given in table I. Perhaps the most important chemical factor is salt content. This factor varies throughout the year, but is relatively low in summer. The values measured by me indicate fresh water to slightly brackish water in summer (according to Økland (1983) fresh water has below 0,5 g l^{-1} salt), and a considerable higher content of salt in the autumn.

Table I. Some chemical and physical parametres measured on the localities with *Tolypella normaniana*

Locality	Date	Conductivity $\mu S\ cm^{-1}$	Salt g l^{-1}	pH	Cl mg l^{-1}	Ca mg l^{-1}	Watertemp ^{0}C
Leirvika	17.07.92	610	0.31	8.8	150	40	14.9
Leirvika	11.10.92	9000	4.51	7.8	100	1250	-
Leirvika	13.07.93	800	0.40	-	175	-	25.6
Leirvika	07.11.93	14770	7.42	7.6	-	-	-
Bjerka	13.07.93	2520	1.26	-	575	-	16.9
Bjerka	17.07.93	1760	0.89	7.6	500	-	12.7
Bjerka	25.08.93	-	-	-	2325	-	-
Bjerka	30.09.93	11740	5.87	8.0	2900	-	-
Mosjøen	17.07.93	216	0.11	-	50	-	12.8

The water temperature in the area varies much, but on sunny days the temperature in the most sheltered parts of the estuaries (especially in Beiarn-fjorden)

can be high. This has a positive effect on the growth of the alga. This was seen clearly in Beiarn where the alga was more developed than in the two other localities.

G. Distribution

Tolypella normaniana is an endemic species to Nordland, Norway. It has been found in the following localities:

Beiarn: Leirvika (ved Soløy), 1867, J.M. Norman (not dated), 29.07.1869 Schlegel and Arnell, 18.07.1992 A. Langangen, 13.07.1993 A.L., 01.08.1993 Mats Nettelbladt, 07.11.1993 Mats Nettelbladt

Hemnes: Hemnes by Prestenget (presumed to be collected by Axel Blytt, 1870)

Hemnes: Røsågas outlet (Sagneset) in Sørfjorden (Ranafjorden), august 1870 A. Blytt and H.W. Arnell, 13.07.1993 A. Langangen, 25.08.1993 Viggo Davidsen, 30.09.1993 Viggo Davidsen (Fig. 14).

Hemnes: Sørfjorden ved Bjerka (Breidvika), 13.07.1993 A. Langangen, 17.07.1993 A.L. (Fig 14)

Vefsn: Vefsnas outlet in Mosjøen, 17.07.1993 A. Langangen.

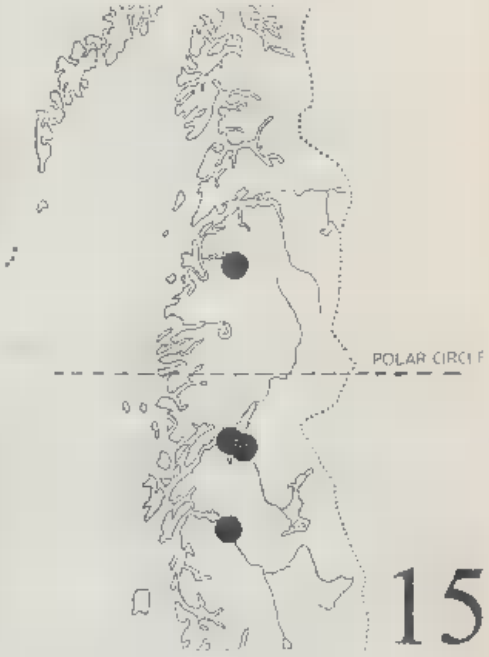

Figure 14. - Map showing the two localities in Sørfjorden (marked by asterix). The dotted area in the sea is the foreshore flat (by ebb sea). This cover great areas. One square = 1km². Copy of map Korgen, M 711 1927 II. Copyright Statens Kartverk 1986. Printed with permission from Statens Kartverk, 1994.

Figure 15. - Distribution of *Tolypella normaniana* in Nordland. The northmost loc. is Beiarn-fjorden, the middle loc. is Sørfjorden and the southmost loc. is Mosjøen.

The distribution is given in figure 15. See also Langangen (1993).The alga is presumed to be more widespread as there is many potential localities in the area (see Elven *et al.*, 1988).

DISCUSSION

Tolypella normaniana belongs to the section *Obtusifolia* of the genus *Tolypella*. This section is characterized by having obtuse branchlet end cells and 2-3 basal impressions on the oospore (on specimens from Beiarn-fjorden I found two basal impressions) (Sawa & Frame, 1974). Two other Scandinavian species of *Tolypella* belong to the same section, *T. glomerata* (Desv.) v. Leonh. and *T. nidifica* (Müller) v. Leonh.. These two species are differentiated by colour (grade of incrustation) and by size of the oospore and membrane structure. All these characters are variable and intermediate forms are often found (Groves & Bullock-Webster, 1920; Moore,1986). This is why Moore (1986) regards *T. glomerata* as a variety of *T. nidifica*. This is not followed by Blindow & Krause (1993). Of the two species *T. normaniana* is, according to my opinion, closest to *T. glomerata* as the length of its oospores is below 300 µm and as it has a fine granulated oospore membrane. This was also suggested by Sydow (1882), but strongly opposed by Migula (1897) and Hasslow (1936). *Tolypella glomerata* is most often found in fresh water in Scandinavia (Hasslow, 1931; Olsen, 1944; Pettersson, 1964; Blindow & Krause, 1989), but occurence in slightly brackish water is known (Olsen, 1944). The other species, *Tolypella nidifica* is only known from brackish water, as is also *T. normaniana*. This is may be the reason why many authors have regarded *T. normaniana* as a variety or subspecies of *T. nidifica* (Corillion, 1957).

The chromosome number of *T. normaniana* counted by me is n = c. 20. This is in accordance with a possible chromosome number of both *T. glomerata* and *T. nidifica*, as Guerlesquin (1966) gives n = c. 20,25 for *T. nidifica* subsp. *occidentalis* R. Corillion (a south European taxon) and n = 15 and c. 20 for *T. glomerata*. Lindenbein (1927) gives n = c. 42 for specimens of *T. nidifica* from the Baltic Sea (near Kiel). Sawa (1974) says that the base number of chromosomes of the European members of *Obtusifolia* is 5 or 10, and that they seem to tolerate a considerable amount of salinity, which is in contrast to fresh water species of the New World where the basal chromosome number seems to be 11. According to Sawa (*op. cit.*) this may reflect two distinct mechanisms of speciation in the group, where consequently *Tolypella normaniana* belongs to the European line as expected.

As the morphological variation of *T. normaniana* is great, it has many characteristics in common with the other species of the *Obtusifolia* group. But *T. normaniana* do also have its own specific characters (Migula, 1897). These are: - There is no sterile whorls as most branchlets in the protonemal whorl are fertile. This is in contrast to *T. nidifica* and *T. glomerata* where one or two whorls have only sterile branchlets. - A permanent protonemal terminal process (Vorkeimspitze) is found on all specimens observed.

This terminal process can be found in young plants of *Chara* and *Tolypella* (Pringsheim, 1862; Bary,1875) and it normally falls off. According to Groves &

Bullock-Webster (1920) the terminal process of *T. glomerata* often persists for some time overlapping the plant.

Tolypella normaniana seems to be a species well adapted to severe ecological conditions, especially the tidal differences in the localities, high fluctuations in salinity (varying from nearly fresh water to strong brackish water) and relatively low temperatures. Other species of *Obtusifolia*, similar in appearance to *T.normaniana* are known from other extreme localities: - *Tolypella antarctica* (A.Br.) R. Corillion, a fresh water species endemic to Kerguelen Island, where the water temperatures are very low (Corillion, 1982; Corillion & Reviers, 1985). - *Tolypella salina* R. Corillion, a species known to France and Spain, and which can stand water with very high degree of salinity (Corillion, 1960; Comelles, 1986).

The localities of *Tolypella normaniana* are the world´s northernmost sites known for the genus *Tolypella*. The other Scandinavian members of the section *Obtusifolia* are as follows: *T. nidifica* can be found in the Baltic north to Oulu in Finland (65^{O}N) (Cedercreutz, 1932), in Denmark (Olsen, 1944), and in a few localities in Southern Norway (Langangen, 1974).

In England it occurs on the Shetland Islands (Moore & Greene, 1983). *T. glomerata* can be found in Denmark (Olsen, 1944) (both fresh and brackish water) and in a few localities in Southern Sweden (all fresh water) (Blindow & Krause, 1989).

Worth mentioning in this connection is also the accompanying species *Chara aspera* in a locality in Sørfjorden. The brackish water form of this species seems to have the same distribution as *T. nidifica*.

Based on these pieces of information on the occurrence of other species of *Tolypella* and *Chara aspera* at this point of writing, it is reasonable to believe that the brackish water species in Nordland have the same place of origin.

The most obvious vector for dispersal of fresh and brackish water algae, including charophytes, is migratory water birds. In a study Proctor (1962) found that oospores of several common North American species of *Chara* could survive the passage through the digestive tract of such birds.

Khan & Sarma (1984) suggest a migration route for *Tolypella nidifica* through the Baltic Sea (Finland) and back to Norway. This is a less probable route, as there are no water birds crossing these landmasses.

Two western routes are more probable. One from Denmark through inland Norway to Nordland and Svalbard by White-fronted Goose, *Anser brachyrhynchus* Baillon, or from Scotland along the Norwegian coast to Nordland and Svalbard by Brent Goose, *Branta leucopsis* Bechstein (Bollingmo, 1991).

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